

A display device

The present invention relates to a display device. In particular, the invention relates to the configuration of an LCD display device.

Current display devices include single driver and x-y driver solutions for driving the LCD. The single driver drives the display in both the x and y directions, whereas the x-y driver has dedicated drivers for each of the x and y directions. Figures 8(a) and (b) of the accompanying drawings illustrate single and x-y driver LCD displays respectively.

Generally, a single driver display device is of suitable size and resolution for a hand-held portable electronic device, such as a radiotelephone. An x-y driver configuration, on the other hand, typically enables the provision of a larger display with similar resolution for use in larger portable devices.

An LCD display generally comprises a pair of glass plates which sandwich a layer of liquid crystals. The glass plates have a series of conductive tracks on one side which contact the sandwiched liquid crystals. The conductive tracks are arranged such that, on a pixelated display, any individual pixel may be independently controlled by applying an appropriate electrical signal. On an LCD device having a single driver device, as shown in Figure 8a, all the conductive track are routed to the single driver. This results in a large area of the glass plates being used solely for routing of the conductive tracks. In particular, three edges of the glass plates are used for routing the conductive tracks. On an LCD device having an X and Y axis driver, as shown in Figure 8b, the routing of the conductive tracks causes the active area of the LCD device to be asymmetrical, since two adjacent edges of the glass plates are used for routing the conductive tracks. In many devices it is preferable, for

aesthetic reasons, to produce symmetrical looking devices. If an LCD with an asymmetrical active area is used to produce a symmetrical looking device, the LCD must be offset within the device. This leads to wastage of space around the LCD, which is highly undesirable. Alternatively, if the LCD is mounted centrally within the device, the active area of the LCD is offset relative to the centre of the device.

According to the present invention, there is provided a display device comprising a liquid crystal display (LCD) comprising first and second liquid crystal cells positioned along a first axis of the display device, a first display driver for driving the first liquid crystal cell, a second display driver for driving the second liquid crystal cell, and means for synchronising the drivers.

This configuration of display device reduces the routing required between the drivers and cells compared with that shown in Figure 8(a), having a single liquid crystal cell of the same size.

Consequently, the resolution is improved for that size of display. Likewise, the size of display is increased for a given resolution. This configuration also has a better contrast ratio over the single driver solution due to the lower multiplexer (MUX) rate. Moreover, the active area to glass ratio is improved, since the number of conductive tracks which need to be routed to each driver is substantially reduced, compared to a single driver arrangement. Subsequently, having a reduced number of conductive tracks further reduces the amount space around the edge of the glass plates used for routing the conductive tracks.

The present invention therefore enables a larger active area to be achieved on a LCD display device. Further, if the display drivers are positioned on opposing ends of LCD display device, the LCD has a symmetrical active

area. Preferably, the first and second display drivers are positioned at opposed sides of the LCD along the first axis of the display device. This enables the device to have a minimum width/height. For example, when the first axis extends in the direction of the height of the LCD (vertical configuration), the display device has a minimum width for a given size of LCD, whereas when the second axis extends in the direction of the width of the LCD (horizontal configuration), the display device has a minimum height for a given size of LCD.

The latter configuration is particularly useful for employment in radiotelephones and the like. Firstly, the minimum height enables the softkeys (function keys associated with items presented on the display) to be close to the display. Secondly, it facilitates the design of a phone that uses a slide to obtain the correct spacing between the microphone and earpiece.

In an embodiment of the invention, the LCD is substantially symmetrical about a bisector. Consequently, the liquid crystal cells are substantially aligned in one direction at least and preferably in both directions so that the device appears to be a unitary large display. Moreover, preferably the LCD and drivers are substantially symmetrical. This results in the usable area of the device being substantially symmetrical and no additional width/depth being required for the display to appear symmetrical in a device such as a radiotelephone. Accordingly, a device having such a configuration has a light weight to active area ratio.

Optionally, the display device further comprises a connector for connecting device circuitry to an external element, and an intermediate element for interfacing the display device and the connector.

This configuration of display device, with an integrated driver, results in a reduction in the number of connections required for connection to the portable device, thus improving reliability and reducing the display space required. Moreover, it facilitates assembly and serviceability of the portable device as well as module reusability.

The intermediate element is preferably located substantially behind the LCD device, so as to further reduce the area of the display module. The area of the display may be yet further reduced by the provision of a display driver element comprising a flexible driver support. Such a support may be folded back from the LCD to contact an intermediate element positioned behind the LCD, for example.

Likewise, the intermediate element may be flexible, thereby enabling bending to contact the driver element (or support) and to bring the connector into contact with the portable device.

The flexible driver support and/or flexible intermediate element may be an flexible printed circuit (FPC) foil, thereby being lightweight and durable.

The intermediate element preferably comprises LCD power control circuitry. This leads to a further reduction in the number of connections required to be made to the portable device, and display space required in the portable device.

Combining an LCD device according to the present invention with an intermediate element provides a self-contained LCD display module. Such a self-contained LCD display module is compact in size, has a large active area and, advantageously, is connectable to an external device or circuit board using a small and reliable connector. This improves the ease and speed of

assembly, and reduces the risk of bad connections being made between the display module and a circuit board.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings of which:

Figure 1 is a block diagram of a display device according to an embodiment of the present invention;

Figure 2 is an exploded view of a display module according to an embodiment of the present invention;

Figure 3a is a perspective view from the front and rear of the display module of Figure 2;

Figure 3b shows various views of the display module of Figure 2;

Figure 4a is a perspective view from the front and rear of the LCD device interconnect;

Figure 4b shows various views of the LCD device interconnect;

Figure 5a illustrates the LCD device according to an embodiment of the present invention;

Figure 5b illustrates a tab of the LCD device of Figure 5a in more detail;

Figures 6a and 6b respectively illustrate horizontal and vertical configurations of the LCD device of different embodiments of the present invention;

Figure 7 illustrates a portable device comprising a display device of the present invention; and

Figures 8a and 8b illustrate conventional display devices, Figure 8a illustrating a device with a single display driver and Figure 8b illustrating a device with an x-y driver.

Figure 1 is a block diagram of a display device according to an embodiment of the present invention. The display device 10 comprises an LCD panel 11, two display drivers 14, 15 and an FPC unit 16. The LCD panel 11 is a "split" display. That is, it consists of two LCDs 12,13 made up of individual cells sandwiched between common glass plates. The glass plates have a conductive coating, as is typical in LCD devices. The LCD 12 is driven by one of the display drivers, namely master display driver 14 and the LCD 13 is driven by the other display driver, slave driver 15. The master and slave drivers 14, 15 are synchronised and the two cells are abutted so that the two LCDs 12, 13 look like a single large display. The FPC unit 16 couples the master and slave display drivers and interfaces with external circuitry to obtain the necessary control and data signals and the like. The FPC unit may comprise the power supply control circuitry as will be explained further below with reference to Figures 2, 4a and 4b.

In this embodiment, serial interface signals (such as serial clock period (SCL), serial interface (SI), data/command indicator (AO), master and slave chip select (master XCS, slave XCS) and reset timing signals) are received by the FPC unit 16 as the serial interface for the display device 10. These signals are forwarded to the display drivers 14, 15. The FPC device also receives the display device power supply (VDD, VSS). The drivers, in turn, output liquid crystal drive signals to drive the respective LCDs 12, 13.

In this example, the display drivers 14, 15 are Seiko Epson 1565 series dot matrix LCD drivers. These drivers have two main kinds of liquid crystal drive pins, SEG pins which are liquid crystal segment drive outputs and COM pins which are common drive outputs. Synchronisation of these devices when used in a master/slave configuration is handled internally by the driver devices.

As can be seen, in this embodiment the master and slave drivers are positioned on each side of the LCD panel 11. In this horizontal configuration, the routing of common drive outputs in the x-direction is reduced when compared, for example, with a single driver device such as that shown in Figure 8a. Consequently, a high resolution can be attained for large displays. In this case, the LCD panel 11 may have a pixel matrix of 111 x 106, pixel size of 0.19 x 0.22 mm and pixel pitch of 0.22 x 0.24 mm. Also, a reduced display height is also possible when compared, for example, with an x-y driver device of equivalent LCD panel size and resolution, such as that shown in Figure 8b. Furthermore, the device is substantially symmetrical, thus avoiding the need to compensate for any asymmetry when used in a device such as a portable device, as is the case with x-y driver devices. This, in turn, results in weight and volume savings.

As will be appreciated, Figure 1 is merely a block diagram, and the circuitry can be implemented in a number of ways. Two alternative configurations are illustrated in Figure 6.

Figure 2 is an exploded view of a display module 20 according to an embodiment of the present invention. The display module 20 comprises a liquid crystal display screen or panel 21, a lightguide 22, a reflector 23, a plastics support frame 24, two LCD tabs 25 and an FPC foil 26. Optionally, the module may also comprise a diffuser between the panel 21 and the

lightguide 22. More detailed views of these components can be seen in Figures 3 to 5. The panel 21 is a split screen as in the Figure 1 embodiment, and likewise has two display drivers. These drivers are located on a respective tab 25, and are referenced 251 in Figure 2. The tabs 25 also each comprise a connector 252 comprising the driver pins etc. which connect to the LCD panel 21, and a connector 253 comprising pins for connecting to the serial interface and for coupling the two drivers 251. The driver connector 252 comprises of the order of 182 pins, and the FPC foil connector 23 comprises of the order of 28 pins. The FPC foil comprises power control circuitry 261 and a board to board connector 262. This board to board connector 262 is a 10 contact connector, of which 9 contacts are used as the serial interface to the display. This connector may plug into a corresponding connector on a PCB of the device in which the display module is to be used.

The number of contacts required to the PCB of the device is minimal due in part to the fact that the drivers are positioned on the tabs 25 of the module 20, (as opposed to the conventional position of on a PCB of the device), and in part due to the fact that the power control circuitry 261 is positioned on the FPC foil 26 of the module. (For example, this module uses only 9 external contacts, compared with in excess of 150 for a conventional single driver device). On an assembly line, the reduction in the number of contacts required provides significant advantages, since smaller connectors are quicker to assemble, cheaper, smaller, lighter and more reliable than connectors having a large number of contacts.

These components are assembled to form a module as shown in Figure 3a. The tabs 25 are fixedly attached to the display panel 21 to form an LCD tab assembly, as is illustrated in Figure 5a. This attachment may, for instance, be by bonding. The support frame 24 is designed with a recess 241 on its front face for receiving the reflector 23, lightguide 22, diffuser (if desired), and

display panel 21. It also comprises a number of notches 242 that correspond to respective tabs 221, 231 on the lightguide 22 and reflector 23 for location purposes.

Once the reflector 23 and lightguide 22 are located within the recess of the support frame, the LCD tab assembly is coupled to the support frame 24. In this embodiment, the support frame 24 comprises a flexible lug 243 on each corner for providing a push fit connection of the LCD panel to the support frame 24.

Subsequently, the FPC foil 26 is positioned on the rear of the support frame 24. The rear face of the support frame 24 is recessed to a depth slightly greater than the joint thickness of the tabs 25 and FPC foil 26. It also has orifices 246 for receiving the drivers 251 and orifices 247 for receiving the power control circuitry etc. Four protrusions 245 on the rear of the support frame serve to locate the main body of the FPC foil 26 by extending into corresponding holes 264 on the foil. The protrusions and holes are arranged so that the connectors 263 of the FPC foil 26 lie over the apertures 246 of the support frame. This assists in the connection of these connectors 263 with those 253 of the tabs 25, as is explained below. A neck 265 of the FPC foil is passed from the rear to the front of the support frame 24 so as to position the connector 262 in front of a connector support 248 portion of the support frame 24. The neck 265 is passed through a cable strap of the connector support 248, which keeps the neck 265 near the side of the connector support. The support 248 also comprises connector support flexible lugs 249 for providing a push fit connection of the connector 262 to the connector support 248. The connector 262 can then be pushed into the connector support to make a push fit connection.

The next assembly step is to connect the connectors 253 of the tabs 25 to corresponding connectors 263 of the FPC foil 26. The tabs 25 have folds 254 corresponding to the side edges of the frame, so that they may be wrapped tightly around the support frame 24. They also comprise holes 263 that correspond to the protrusions 245 on the rear of the support frame so as to locate the tab connectors 253 over those 263 of the FPC foil 26. As mentioned above, the connectors are located over the apertures 246 to assist in connection of the connectors. In this embodiment, prior to locating the tabs, a silicon rubber insulator is positioned in the apertures 246 behind the FPC foil connectors 263. The tabs are then located and the FPC foil and tab connectors 253, 263 are heat bonded together (by heating and applying pressure). The insulator is then removed from the module 20. Alternatively, of course, the insulator could be inserted prior to location of the FPC foil or after location of both the FPC foil 26 and the tabs 25.

Figure 3b shows different views of the display module of Figure 2, namely, front, rear, top, bottom and left side views. It also illustrates a pixel array. As mentioned above, in this embodiment, the dimensions shown may have a pixel size ($a \times d$) of 0.19×0.22 mm and pixel pitch ($b \times e$) of 0.22×0.24 mm. Consequently, in this case there is a horizontal pixel gap c of 0.3 mm and a vertical pixel gap f of 0.2 mm. The LCD cells can be abutted such that only a 0.3mm gap is apparent where they abut which is not noticeable by the human eye.

Figures 4a and 4b illustrate the FPC foil 26 in more detail. The connectors 263, components and tracking 261 may be applied to the foil using any of the known techniques.

Figure 5a shows front, left side and two bottom views of the LCD tab assembly comprising the tabs 25 and the display panel 21. One bottom view

shows the assembly flat, and the other with the tabs folded along the folds 254. Figure 5b shows the tabs 25 in more detail. Preferably, the tabs 25 are made of FPC foil and again the connectors, drivers and tracking are applied to the foil using any of the known techniques.

Figure 6 illustrates two different configurations of a display device with a "split screen", Figure 6a showing a display module 61 with a horizontal configuration, and Figure 6b showing a display module 69 with a vertical configuration. Each display module comprises an LCD panel 62 consisting of two LCDs 65, 66, and two display drivers 67, 68. The LCD 65 is driven by display driver 61, and the LCD 66 is driven by display driver 68. The drivers 67, 68 are synchronised and the cells of LCDs 65, 66 are abutted so that the two LCDs look like a single large display. As in the figure 2 embodiment, the drivers are on tabs 63, 64 and fold under the module to reduce the modules area. The tabs and or a separate element comprise the driver coupling and module interface. Both configurations enable the provision of a small compact module with minimum area and weight to display content. The area of the module is compact and the glass area to active area ratio is excellent. The horizontal configuration provides a minimum product height, whereas the vertical configuration provides a minimum product width.

A radiotelephone 70 comprising a display device 71 of the invention is illustrated in Figure 7. This radiotelephone has all the usual components of a radiotelephone, including an earpiece 74 and microphone 75. In this embodiment, the phone has a slide to extend the gap between the earpiece 74 and microphone 75 to that between a user's ear and mouth when the phone is to be used for conversation. This radiotelephone further comprises function keys 72. These keys are softkeys, that is, their function alters depending upon the item presented on the display 71. Preferably, the display device 71 in this radiotelephone 70 has the horizontal configuration of Figure

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6b as its minimum height enables the softkeys (function keys associated with items presented on the display) to be positioned close to the display. Secondly, it facilitates the design of an well proportioned slide phone.

The present invention may be embodied in other specific forms without departing from its essential attributes. Accordingly reference should be made to the appended claims and other general statement's herein rather than to the foregoing specific description as indicating the scope of invention.

Furthermore, each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features. In this regard, the invention includes any novel features or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed.

The appended abstract as filed herewith is included in the specification by reference.